WE CLAIM:

1. A process for providing a hydrogen-containing gas stream to at least one fuel cell anode, comprising:

providing a hydrogen-containing feed gas stream that includes at least one contaminant;

introducing the hydrogen-containing feed gas stream into an adsorption module having at least a first adsorbent and at least one second material selected from a second adsorbent, a steam reforming catalyst, and a water gas shift reaction catalyst, wherein the first adsorbent and the second adsorbent are chemically distinct and at least one of the first adsorbent or the second adsorbent preferentially adsorbs the contaminant in the hydrogen-containing feed gas stream to produce a purified hydrogen-containing gas stream; and

introducing the purified hydrogen-containing gas stream to the fuel cell anode.

2. The process according to claim 2, wherein the contaminant is carbon monoxide and at least one of the first adsorbent or second adsorbent comprises a carbon monoxide-selective adsorbent.

3. The process according to claim 2, wherein the carbon monoxide-selective adsorbent is selected from Na-LSX, Ca-LSX, Li-LSX, Li-exchanged chabazite, Ca-exchanged chabazite, Sr-exchanged chabazite, a Cu(I)-containing material, a Ag(I)-containing material, or a mixture thereof.

4. The process according to claim 1, further comprising introducing the hydrogen-containing feed gas stream into the adsorption module at a temperature of about 80°C to about 200°C.

5. The process according to claim 1, further comprising at least one additional adsorbent.

6. The process according to claim 1, wherein the adsorption module comprises a rotary pressure swing adsorption module.

7. The process according to claim 1, wherein the fuel cell comprises a polymer electrolyte membrane fuel cell.

8. The process according to claim 1, further comprising providing a reforming or partial oxidation system that produces the hydrogen-containing feed gas stream.

9. The process according to claim 2, wherein the carbon monoxide-selective adsorbent is selected from a Cu(I)-containing material, a Ag(I)-containing material, or a mixture thereof.

10. The process according to claim 1, wherein the first adsorbent preferentially adsorbs carbon dioxide compared to water vapor.

11. The process according to claim 1, wherein the first adsorbent comprises an alkali-promoted material and at least one of the steam reforming catalyst and the water gas shift reaction catalyst is present.

12. The process according to claim 11, wherein the steam reforming catalyst is selected from a methanol steam reforming catalyst or a methane steam reforming catalyst.

13. A process for providing a hydrogen-containing gas stream to at least one fuel cell anode, comprising:

providing a hydrogen-containing feed gas stream that includes at least a first contaminant and at least a second contaminant;

preferentially separating at least a portion of the first contaminant from the hydrogen-containing feed gas stream in a first separation zone;

preferentially separating at least a portion of the second contaminant from the hydrogen-containing feed gas stream in a second separation zone; and

introducing the resulting purified hydrogen-containing gas stream to the fuel cell anode.

14. The process according to claim 13, wherein the first contaminant is water vapor and the second contaminant is at least one carbon oxide.

15. The process according to claim 13, wherein the preferential separation of the first contaminant occurs prior to the preferential separation of the second contaminant.

16. The process according to claim 13, wherein the first separation zone comprises a first adsorbent bed and the second separation zone comprises a second adsorption bed.

17. The process according to claim 13, wherein the preferential separation of the first and second contaminants occurs via adsorption.

18. The process according to claim 13, wherein the hydrogen-containing feed gas stream is produced by a reforming or partial oxidation system.

19. The process according to claim 13, wherein the fuel cell comprises a polymer electrolyte membrane fuel cell.

20. The process according to claim 13, further comprising preferentially separating at least one additional contaminant in at least one additional separation zone.

21. The process according to claim 20, wherein water vapor is preferentially separated in the first separation zone, carbon dioxide is preferentially separated in the second separation zone, and carbon monoxide is separated in a third separation zone.

22. The process according to claim 21, wherein the first separation zone comprises a desiccant, the second separation zone comprises a zeolite, and the third separation zone comprises a zeolite.

23. The process according to claim 13, wherein the first or second contaminant comprises carbon monoxide and the process further comprises reacting the carbon monoxide with water vapor in the first or second separation zones.

24. A process for providing a hydrogen-containing gas stream to at least one fuel cell anode, comprising:

providing a hydrogen-containing feed gas stream that includes at least a first contaminant and at least a second contaminant;

contacting the hydrogen-containing feed gas stream with at least a first adsorbent and at least a second adsorbent under conditions sufficient to separate at least a portion of the first contaminant and at least a portion of the second contaminant from the hydrogen-containing feed gas stream; and

introducing the resulting purified hydrogen-containing gas stream to the fuel cell anode.

25. A process for separating carbon monoxide from a hydrogen-containing gas stream that is provided to at least one fuel cell anode, comprising:

providing a hydrogen-containing feed gas stream that includes carbon monoxide;

providing at least one rotary pressure swing adsorption module that includes at least one adsorbent selected from Na-LSX, Ca-LSX, Li-LSX, Li-exchanged chabazite, Ca-exchanged chabazite, Sr-exchanged chabazite, a Cu(I)-containing material, a Ag(I)-containing material, or a mixture thereof;

introducing the hydrogen-containing feed gas stream into the rotary pressure swing module to separate at least a portion of the carbon monoxide from the hydrogen-containing feed gas stream; and

introducing the resulting purified hydrogen-containing gas stream into the fuel cell anode.

26. The process according to claim 25, wherein the adsorbent comprises a Cu(I)-containing material, a Ag(I)-containing material, or a mixture thereof.

27. A process for providing a hydrogen-containing gas stream to at least one fuel cell anode, comprising:

providing a hydrogen-containing gas stream that includes carbon monoxide;

introducing the hydrogen-containing gas stream into a pressure swing adsorption module that includes at least one carbon monoxide-selective adsorbent to produce a purified hydrogen-containing gas stream; and

introducing the purified hydrogen-containing gas stream to the fuel cell anode.

28. A process according to claim 27, wherein the carbon monoxide-selective adsorbent comprises a Cu(I)-containing material, a Ag(I)-containing material, or a mixture thereof.

29. A process for providing a hydrogen-containing gas stream to at least one fuel cell anode, comprising:

providing an oxygen-enriched gas stream;

providing a mixture of the oxygen-enriched gas stream and a fuel in an autothermal reforming or partial oxidation reactor to produce a hydrogen-containing gas stream that includes at least one carbon oxide contaminant;

separating at least a portion of the carbon oxide contaminant from the hydrogen-containing gas stream; and

introducing the resulting purified hydrogen-containing gas stream into the fuel cell anode.

30. The process according to claim 29, further comprising providing a pressure swing adsorption module for producing the oxygen-enriched gas stream.

31. An electrical current generating system comprising:

a hydrogen-containing gas source;

at least one adsorption module that can at least partially purify the hydrogen-containing gas, wherein the adsorption module includes at least a first adsorbent and at least one second material selected from a second adsorbent, a steam reforming catalyst, and a water gas shift reaction catalyst, the first adsorbent and the second adsorbent being chemically distinct; and

at least one fuel cell defining an anode inlet that can receive the purified hydrogen-containing gas stream from the adsorption module.

32. The system according to claim 31, wherein the hydrogen-containing gas source comprises a reformer or partial oxidation reactor.

33. The system according to claim 31, wherein the adsorption module comprises a rotary pressure swing adsorption module.

34. The system according to claim 31, wherein the first adsorbent is disposed in a first zone and the second material is disposed in a second zone.

35. The system according to claim 34, wherein the first zone and the second zone are disposed adjacently along a hydrogen-containing gas flow path defined in the adsorption module.

36. The system according to claim 31, further comprising an anode recirculation conduit fluidly communicating between a fuel cell anode outlet and an inlet defined in the adsorption module.

37. The system according to claim 31, wherein at least one of the first adsorbent or second adsorbent comprises a carbon monoxide-selective adsorbent.

38. The system according to claim 37, wherein the carbon monoxide-selective adsorbent is selected from Na-LSX, Ca-LSX, Li-LSX, Li-exchanged chabazite, Ca-exchanged chabazite, Sr-exchanged chabazite, a Cu(I)-containing material, a Ag(I)-containing material, or a mixture thereof.

39. The system according to claim 31, wherein the steam reforming catalyst or the water gas shift reaction catalyst is selected from a Cu-ZnO catalyst, a transition metal carbonyl complex catalyst, or a catalyst comprising a transition group metal inserted into a zeolite cage.

40. The system according to claim 34, further comprising at least one additional zone of at least one additional adsorbent.

41. The system according to claim 31, wherein the first adsorbent preferentially adsorbs carbon dioxide compared to water vapor and at least one of the steam reforming catalyst or the water gas shift reaction catalyst is present.

42. The system according to claim 41, wherein the first adsorbent comprises an alkali-promoted material.

43. The system according to claim 31, wherein the carbon monoxide-selective adsorbent is selected from a Cu(I)-containing material, a Ag(I)-containing material, or a mixture thereof.

45. The system according to claim 40, wherein the first adsorbent comprises a desiccant, the second adsorbent comprises a zeolite, and the additional adsorbent comprises a zeolite.

46. The system according to claim 31, wherein at least one of the first adsorbent or second adsorbent comprises a zeolite, an activated charcoal, or a Cu(I)-containing material.

47. The system according to claim 32, wherein the reformer or partial oxidation reactor comprises a first burner and a second burner.

48. The system according to claim 47, wherein the first burner receives an exhaust gas from the adsorption module and the second burner receives a hydrocarbon fuel.

49. An electrical current generating system comprising:

a hydrogen-containing gas source;

at least one pressure swing adsorption module fluidly coupled to the hydrogen-containing gas source, the pressure swing adsorption module including at least one carbon monoxide-selective adsorbent; and

at least one fuel cell anode fluidly coupled to the pressure swing adsorption module.

50. The system according to claim 49, wherein the carbon monoxide-selective adsorbent is selected from a Cu(I)-containing material, a Ag(I)-containing material, or a mixture thereof.

51. A system for supplying hydrogen gas to a fuel cell anode, comprising:

a hydrogen gas generating system that includes an outlet for discharging a hydrogen-containing gas that includes at least a first contaminant and a second contaminant;

a first contaminant separation zone that fluidly communicates with the outlet of the hydrogen gas generating system;

at least one second contaminant separation zone that fluidly communicates with the first contaminant separation zone and includes an outlet for discharging a purified hydrogen gas; and

at least one fuel cell anode that fluidly communicates with the outlet for the second contaminant separation zone.

52. The system according to claim 51, wherein the hydrogen gas generating system comprises a reformer or partial oxidation reactor and at least one of the first contaminant or second contaminant comprises a carbon oxide.

53. The system according to claim 51, wherein the first contaminant separation zone comprises a first adsorbent and the second contaminant separation zone comprises a second adsorbent.

54. The system according to claim 53, wherein the first contaminant separation zone and the second contaminant separation zone are disposed within a rotary pressure swing adsorption module.

55. A system for supplying hydrogen gas to a fuel cell anode, comprising:

a hydrogen-containing gas source;

at least one rotary pressure swing adsorption module that can at least partially purify the hydrogen-containing gas, wherein the rotary pressure swing adsorption module includes at least one adsorbent selected from Na-LSX, Ca-LSX, Li-LSX, Li-exchanged chabazite, Ca-exchanged chabazite, Sr-exchanged chabazite, a Cu(I)-containing material, a Ag(I)-containing material, or a mixture thereof; and

at least one fuel cell having an anode inlet that can receive the purified hydrogen-containing gas stream from the rotary pressure swing adsorption module.

56. The system according to claim 55, wherein the adsorbent is selected from a material that includes a Cu(I)-containing material, a Ag(I)-containing material, or a mixture thereof.

57. An electrical current generating system comprising:

at least one first pressure swing adsorption module having an outlet for discharging an oxygen-enriched gas stream;

an autothermal reforming or partial oxidation reactor that can combust fuel and the oxygen-enriched gas stream to produce a hydrogen-containing gas;

at least one second pressure swing adsorption module that can at least partially purify the hydrogen-containing gas; and

at least one fuel cell having an anode inlet that can receive the purified hydrogen-containing gas from the second pressure swing adsorption module.

58. A process for providing a hydrogen-containing gas stream and an oxygen-enriched gas stream to a fuel cell, comprising:

providing at least one first pressure swing adsorption module that produces an oxygen-enriched gas stream, the first pressure swing adsorption module including at least one device selected from a first compressor or first vacuum pump;

providing at least one second pressure swing adsorption module that produces a purified hydrogen gas stream and a separation exhaust gas stream, the second pressure swing adsorption module including at least one device selected from a second compressor or second vacuum pump;

introducing the oxygen-enriched gas stream and the purified hydrogen gas stream into a fuel cell; and

introducing the separation exhaust gas stream as a fuel into a combustion engine for driving at least one device selected from the first compressor, first vacuum pump, second compressor, second vacuum pump, or an electric generator.

59. The process according to claim 58, further comprising mixing a portion of the purified hydrogen gas stream with the separation exhaust gas stream as a fuel for the combustion engine.

60. The process according to claim 58, wherein the fuel cell produces a cathode exhaust gas stream that includes water and the process further comprises cooling the combustion engine with the water from the cathode exhaust gas stream.

61. The process according to claim 60, further comprising vaporizing the coolant water from the combustion engine and introducing the resulting water vapor into a reformer that produces the hydrogen-containing gas feed stream.

62. The process according to claim 58, wherein the combustion engine produces an engine exhaust gas stream and the process further comprises heating a hydrogen gas generating system with the engine exhaust gas stream.

63. The process according to claim 58, further comprising:

mixing liquid water and a hydrocarbon fuel stream resulting in a coolant mixture;

introducing the coolant mixture into a coolant jacket juxtaposed with the combustion engine;

vaporizing the coolant mixture to form a steam/fuel vapor mixture;

subjecting the steam/fuel vapor mixture to reaction conditions sufficient for generating a hydrogen-containing gas stream; and

introducing the hydrogen-containing gas stream into the second pressure swing adsorption module.

64. A process for providing a hydrogen-containing gas stream to a fuel cell;

providing a fuel cell defining a coolant passage and an anode inlet for receiving a hydrogen-containing gas stream;

mixing liquid water and a hydrocarbon fuel stream resulting in a coolant mixture;

introducing the coolant mixture into the coolant passage of the fuel cell;

vaporizing the coolant mixture to form a steam/fuel vapor mixture;

subjecting the steam/fuel vapor mixture to reaction conditions sufficient for generating a hydrogen-containing gas stream; and

introducing the hydrogen-containing gas stream into the fuel cell anode inlet.

65. The process according to claim 64, wherein the hydrocarbon fuel stream comprises methanol, ethanol, or a mixture thereof.

66. The process according to claim 64, wherein the vaporizing of the coolant mixture comprises flash evaporating of the coolant mixture.

67. The process according to claim 64, further comprising purifying the hydrogen-containing gas stream prior to introducing the hydrogen-containing gas stream into the fuel cell anode inlet.

68. The process according to claim 67, wherein the purification of the hydrogen-containing gas stream occurs via pressure swing adsorption.

69. The process according to claim 64, wherein the steam/fuel vapor mixture is subjected to reforming or partial oxidation to generate the hydrogen-containing gas stream.

70. The process according to claim 64, wherein the fuel cell further defines a cathode outlet for discharging a cathode exhaust gas stream that includes cathode water vapor, the process further comprising condensing at least a portion of the cathode water vapor, separating the resulting liquid water stream from the cathode exhaust gas stream, and mixing the liquid water stream with the hydrocarbon fuel stream.

71. An electrical current generating system, comprising:

at least one hydrogen gas separation module that includes a first outlet for discharging a purified hydrogen gas and a second outlet for discharging a separation exhaust gas;

at least one fuel cell defining an anode inlet that fluidly communicates with the first outlet of the hydrogen gas separation module; and

a combustion engine defining a fuel inlet that fluidly communicates with the second outlet of the hydrogen gas separation module.

72. The system according to claim 71, wherein the hydrogen gas separation module comprises a pressure swing adsorption module.

73. The system according to claim 72, wherein the hydrogen gas separation module comprises a rotary pressure swing adsorption module.

74. The system according to claim 71, further comprising at least one first pressure swing adsorption module that includes an outlet for discharging an oxygen-enriched gas stream and at least one compressor or pump, wherein a shaft coupled to the combustion engine drives at least the compressor or pump.

75. The system according to claim 71, wherein the fuel cell further defines a cathode outlet for discharging a cathode exhaust gas stream that includes water, the combustion engine further includes a cooling jacket, and the system further comprises a conduit fluidly communicating between the fuel cell cathode outlet and the combustion engine cooling jacket.

76. The system according to claim 71, further comprising a hydrogen gas generating system that fluidly communicates with the hydrogen gas separation module, wherein the hydrogen gas generating system comprises a reformer or partial oxidation reactor and the combustion engine further includes a cooling jacket that defines an outlet for a water stream that fluidly communicates with the reformer or partial oxidation reactor.

77. The system according to claim 71, wherein the fuel cell comprises a polymer electrolyte membrane fuel cell.

78. An electrical current generating system, comprising:

a fuel cell defining an anode inlet for receiving a hydrogen-containing gas stream, and a coolant passage having a coolant inlet and a coolant outlet;

a water source fluidly communicating the coolant inlet;

a hydrocarbon fuel source fluidly communicating with the coolant inlet;

a hydrogen gas generating module that includes an outlet for discharging a hydrogen-containing gas stream and a fuel inlet that fluidly communicates with the coolant outlet; and

a first conduit fluidly communicating between the hydrogen gas generating module outlet and the fuel cell anode inlet.

79. The system according to claim 78, wherein the hydrocarbon fuel comprises methanol, ethanol, or a mixture thereof.

80. The system according to claim 78, further comprising a first pressure swing adsorption module for purifying the hydrogen-containing gas stream prior to introduction of the hydrogen-containing gas stream into the fuel cell anode inlet.

81. The system according to claim 80, wherein the pressure swing adsorption module comprises a rotary pressure swing adsorption module.

82. The system according to claim 78, further comprising a pressure swing adsorption module that includes an outlet for discharging an oxygen-enriched stream, and a third conduit fluidly communicating between the pressure swing adsorption module outlet and a fuel cell cathode inlet.

83. The system according to claim 82, wherein the pressure swing adsorption module comprises a rotary pressure swing adsorption module.

84. The system according to claim 82, wherein the first pressure swing adsorption module includes an outlet for discharging a purification exhaust gas, and the system further comprises a second pressure swing adsorption module that includes a first outlet for discharging an oxygen-enriched stream and a second outlet for discharging an enrichment exhaust gas, and a third conduit fluidly communicating between the purification exhaust gas outlet, the enrichment exhaust gas outlet, and at least one burner for the hydrogen gas generating module.

85. The system according to claim 78, further comprising a separator fluidly communicating with the first conduit for separating water from the cathode exhaust gas stream.

86. The system according to claim 78, wherein the fuel cell further defines a cathode outlet for discharging a cathode exhaust gas stream, and the system further comprises a

second conduit fluidly communicating between the fuel cell cathode outlet and the coolant inlet.